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# (2*E*)-*N*-(2-Iodo-4,6-dimethylphenyl)-2-methylbut-2-enamide

**David L. Hughes,[a] Michael C. McDermott,[a] G. Richard Stephenson[a]* and Andrew J. Walkington[b]**

[a]Wolfson Materials and Catalysis Centre, School of Chemical Sciences and Pharmacy, University of East Anglia, Norwich NR4 7TJ, England, and [b]GlaxoSmithKline, Medicines Research Centre, Gunnels Wood Road, Stevenage, Hertfordshire SG1 2NY, England
Correspondence e-mail: g.r.stephenson@uea.ac.uk

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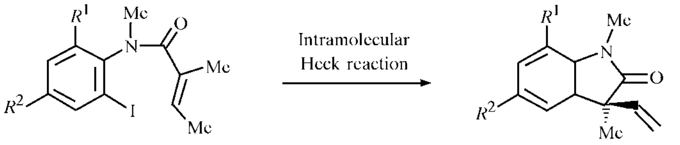
The title compound, $C_{14}H_{18}INO$, crystallizes as *+sc*/*+sp*/*+sc* 2-iodoanilide molecules (and racemic opposites) and shows significant intermolecular I···O interactions in the solid state, forming dimeric pairs about centres of symmetry. Under asymmetric Heck conditions, the *S* enantiomer of the dihydroindol-2-one was obtained using (*R*)-(+)-2,2′-bis(diphenylphosphino)-1,1′-binaphthyl [(*R*)-BINAP], suggesting a mechanism that proceeds by oxidative addition to give the title (*P*) enantiomer of the compound and pro-*S* coordination of the *Re* face of the alkene in a conformation similar to that defined crystallographically, except that rotation about the C—C bond of the butenyl group is required.

## Comment

The *M* enantiomer of the title iodoanilide, (I*b*), gives rise (Lapierre *et al.*, 2007), predominantly, to (*R*)-1,3-dihydroindol-2-one, (II*b*), when cyclized (see scheme) using an intramolecular Heck reaction (Beletskaya & Cheprakov, 2000) under Hartwig's low-temperature conditions (Stambuli *et al.*, 2001). The crystallographic study reported in that work (Lapierre *et al.*, 2007) employed a 4-bromo-2-iodoaryl analogue, (I*c*), not the 2,4-dimethyl substrate itself. Furthermore, the conformation adopted in the solid state for the 4-bromo case was different from that which we had described earlier (McDermott *et al.*, 2006) for Overman's original substrate (I*a*) (Ashimori & Overman, 1992; Mandin & Overman, 1992; Ashimori *et al.*, 1998) and a symmetrized analogue.



(I) (II)

(*a*) $R^1=R^2=H$
(*b*) $R^1=R^2=Me$
(*c*) $R^1=Me$, $R^2=Br$

The structure now defined for (I*b*) (Fig. 1*a*) resembles that needed (McDermott *et al.*, 2006) for cyclization, except that rotation about C21—C22 is required. Our crystallographic results for (I*a*) (McDermott *et al.*, 2006) and (I*b*), however, indicate that strong intermolecular I···O interactions (Messina *et al.*, 2001) are present [3.071 (6) Å in (I*a*) and 2.964 (3) Å in (I*b*)], significantly shorter than the sum of the van der Waals radii (3.55 Å; Pauling, 1960). Unlike (I*a*), however, which was characterized as homochiral crystals containing chains of ribbons of *+ac*/*−sp*/*−sc* 2-iodoanilides (Table 1 and Fig. 2) linked by a zigzag pattern of I···O interactions, the title compound crystallizes with the *+sc*/*+sp*/*+sc* conformation and is linked into dimer pairs about an inversion centre through short I···O interactions. The conformations adopted by 2-iodoanilide butenoyl amides of this type are best described (Curran & Heffner, 1990; McDermott *et al.*, 2006) by consideration of three planes (Fig. 3), corresponding to the three roughly planar sections of the molecule (the aromatic ring, the amide and the alkene). Table 1 compares data for these key features of the molecule.

The 2-iodo-4,6-dimethyl substrate, (I*b*), gave the racemic indol-2-one derivative in 86% yield. Reaction of (I*b*) with $Pd_2(dba)_3$ and (*R*)-BINAP [(*R*)-(+)-2,2′-bis(diphenylphos-

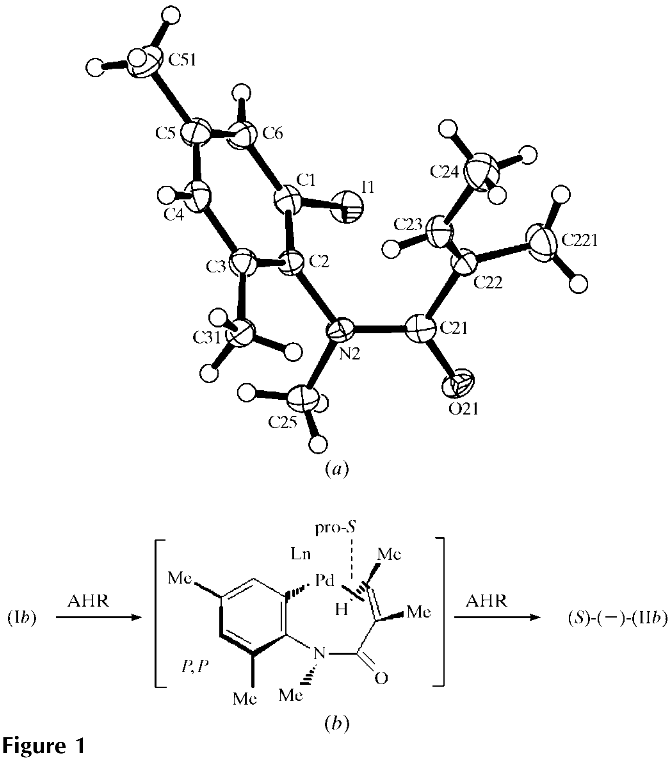


**Figure 1**
(*a*) The structure of (*P*)-(I*b*), taken from a racemic crystal, showing the atom-numbering scheme. Displacement ellipsoids are drawn at the 50% probability level and H atoms are shown as small spheres of arbitary radii. (*b*) The proposed conformation after the oxidative addition step of the asymmetric Heck reaction (AHR) using (*R*)-BINAP, which retains the *P* relationship between N2—C21—O21 and C21—N2—C25 but requires rotation about C21—C22.

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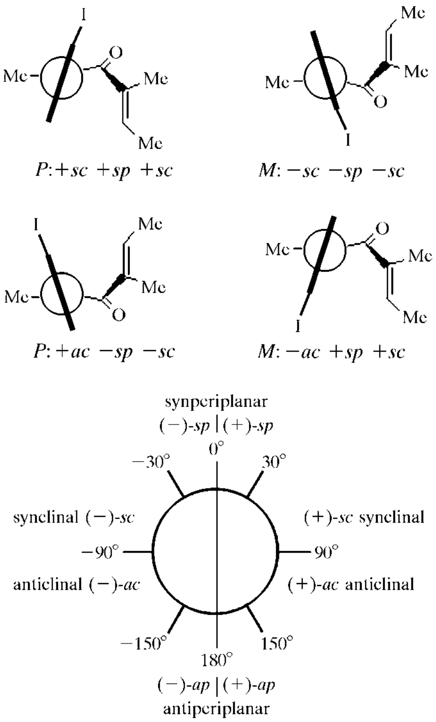

**Figure 2**
Projections down the C2—N2 bond of the *P* and *M* enantiomers for examples of *sc*/*sp*/*sc* and *ac*/*sp*/*sc* geometries of 2-iodoanilide butenoyl amides.

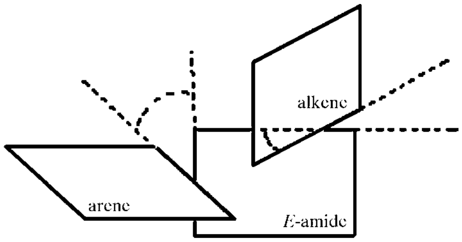

**Figure 3**
The principal planes of 2-iodoanilide, (I).

phino)-1,1′-binaphthyl] under Overman's silver phosphate conditions [silver phosphate (Aldrich) in DMA (*N*,*N*-dimethylacetamide) (McDermott *et al.*, 2007)] gave the same product, (II*b*), with an enantiomeric excess (e.e.) of 25%. This interconversion is thus consistent with oxidative addition to (*P*)-(I*b*) and pro-*S* coordination of the *Re* face of the alkene, in the conformation shown in Fig. 1(*b*).

## Experimental

Compound (I*b*) was synthesized from 2,4-dimethylaniline using procedures based on the iodination of anilines by Berliner & Hann (1925), and the Takahashi method for the methylation of anilides (Fujikura *et al.*, 1995). Purification was achieved by column chromatography on silica using hexane–dichloromethane (1:1 *v*/*v*) as the eluent and recrystallization from hexane. (2*E*)-*N*-(2-Iodo-4,6-dimethylphenyl)-2-methylbut-2-enamide was obtained as short pale-turquoise needles (yield 8.27 g, 31%; m.p. 382–385 K). Additional details of the synthesis and spectroscopic data are given in the archived CIF.

*Crystal data*

$C_{14}H_{18}INO$
$M_r = 343.19$
Triclinic, $P\overline{1}$
$a = 8.8872$ (6) Å
$b = 9.3897$ (6) Å
$c = 10.1875$ (7) Å
$\alpha = 66.389$ (4)°
$\beta = 67.135$ (4)°
$\gamma = 76.842$ (5)°
$V = 715.14$ (8) Å$^3$
$Z = 2$
Mo $K\alpha$ radiation
$\mu = 2.23$ mm$^{-1}$
$T = 120$ (2) K
0.45 × 0.3 × 0.14 mm

*Data collection*

Bruker–Nonius KappaCCD area-detector diffractometer
Absorption correction: multi-scan (*SADABS*; Sheldrick, 2003)
$T_{\min} = 0.612$, $T_{\max} = 1.00$
15106 measured reflections
3278 independent reflections
2812 reflections with $I > 2\sigma(I)$
$R_{\rm int} = 0.043$

*Refinement*

$R[F^2 > 2\sigma(F^2)] = 0.033$
$wR(F^2) = 0.086$
$S = 1.14$
3278 reflections
163 parameters
H-atom parameters constrained
$\Delta\rho_{\max} = 0.73$ e Å$^{-3}$
$\Delta\rho_{\min} = -1.12$ e Å$^{-3}$

H atoms were included in idealized positions and refined using a riding model, with C—H = 0.93 Å and $U_{\rm iso}$(H) = $1.2U_{\rm eq}$(C) for the trigonal planar groups, and C—H = 0.96 Å and $U_{\rm iso}$(H) = $1.5U_{\rm eq}$(C) for the methyl groups. Two persistent difference peaks were assigned and refined as partial disordered I atoms, I2 and I3, with site occupancies of 0.0206 (12) and 0.015, respectively. The first of these atoms, I2, is close to C31 and represents a molecule with the benzene group rotated by 180° about the C2···C5 axis, *i.e.* with atom I1 and the C31 methyl group interchanged. Consequently, the site-occupation factors of atom I1 and the C31 methyl group were constrained to 0.9794 (12), but the minor disorder site for the C31 methyl group was not included in the model. The second peak was also assigned as a low-occupancy site for an I atom, I3, which lies *ca* 2.2 Å from atom I1 and quite separate from any other atom. A data set collected from a second crystal showed the same residual electron-density peaks. Examination of reconstructed zero-layer precession images showed severe streaking of the reflections and possibly some satellite reflections. One explanation for these images could be that the crystals consist of stacked plates that are very slightly slipped relative to one another. Consequently, it is likely that the residual peak assigned as atom I3 is an artefact of the data. In the final difference map, the highest residual peaks (to *ca* 0.7 e Å$^{-3}$) were close to the major-occupancy I atom, I1.

Data collection: *COLLECT* (Nonius, 1998); cell refinement: *DENZO* (Otwinowski & Minor, 1997) and *COLLECT*; data reduction: *DENZO* and *COLLECT*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 1997); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *ORTEP-3 for Windows* (Farrugia, 1997); software used to prepare material for publication: *SHELXL97*.

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**Table 1**
Comparison of structural properties of 2-iodoanilides with butenoyl amide groups.

| Starting material | *R*$_1$ | *R*$_2$ | Conformation[a] (*N*-aryl bond/ amide bond/ acrylate bond) | *N*-Aryl bond C1—C2—N2—C21[b] (°) | Amide bond C2—N2—C21—C22[c] (°) | Acrylate bond N2—C21—C22—C23[d] (°) | Acrylate bond O21—C21—C22—C23 (°) | Alkene bond C21—C22—C23—C24[e] (°) | Temperature (K) | Product | Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (I*a*) (homochiral[f]) | H | H | *P*[g],*P*[h]: +*ac*/−*sp*/−*sc* | 117.3 (7)[i] | −17.9 (9)[i] | −51.4 (9)[i] | 125.1 (7)[i] | −172.1 (7)[i] | 140 | (II*a*) | *i* |
| (homochiral[f]) | | | *M*,*M*: −*ac*/+*sp*/+*sc* | −116.5 (3)[i] | 16.3 (4)[i] | 52.9 (4)[i] | −125.3 (3)[i] | 172.5 (3)[i] | 293 | | *i* |
| (I*b*) (racemic[j]) | Me | Me | *P*,*M*: +*sc*/+*sp*/+*sc* | 68.1 (5)[k] | 17.5 (5)[k] | 39.9 (5)[k] | −136.6 (4)[k] | 173.1 (4)[k] | 120 | (II*b*)[k,l] | *k*, *l* |
| (racemic[j]) | | | *M*,*P*: −*sc*/−*sp*/−*sc* | −68.1 (5)[k] | −17.5 (5)[k] | −39.9 (5)[k] | 136.6 (4)[k] | −173.1 (4)[k] | | | *k*, *l* |
| (I*c*) (homochiral[f]) | Me | Br | *P*,*M*: +*sc*/+*sp*/+*sc* | 71.1[l] | 10.2[l] | 49.2[l] | −130.7[l] | 173.1[l] | 100 | (II*c*)[l] | *l* |

Notes: (*a*) see McDermott *et al.* (2006) and Lapierre *et al.* (2007). The conformational differences through the sequence of atoms C1–C23 can be assigned from a series of three torsion angles, C1—C2—N2—C21, C2—N2—C21—C22 and N2—C21—C22—C23, selected for this purpose; (*b*) shows the relationship between the arene and *E*-amide planes illustrated in Fig. 3; (*c*) shows the deviation from planarity in the amide (a small angle or zero for C2—N2—C21—C22 corresponds to an *E*-amide); (*d*) shows the relationship between the *E*-amide and alkene planes illustrated in Fig. 3; (*e*) shows the deviation from planarity in the alkene; (*f*) data for *P* and *M* forms, measured individually from enantiomerically pure crystals; (*g*) the *P* configuration corresponds to a positive torsion angle for C1—C2—N2—C21; (*h*) the *P* configuration corresponds to a positive torsion angle for O21—C21—C22—C23; (*i*) McDermott *et al.* (2006); (*j*) values for *P* and *M* forms taken from data for a racemic crystal; (*k*) this work; (*l*) Lapierre *et al.* (2007).

Supplementary data for this paper are available from the IUCr electronic archives (Reference: LN3060). Services for accessing these data are described at the back of the journal.

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